BEHAVIOUR OF COLD-FORMED SECTION WITH MULTIPLE OPENINGS UNDER COMPRESSION

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I/We* hereby declare that I/We* have checked this thesis/project* and in my/our* opinion, this thesis/project* is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Unsur struktur keluli yang terbentuk sejuk telah digunakan secara meluas dalam industri pembinaan dan telah muncul sebagai penyelesaian ekonomi pilihan untuk bangunan komersial dan perindustrian satu tingkat. Bahagian terbina dalam keluli terbentuk sejuk biasanya digunakan sebagai unsur mampatan untuk membawa beban yang lebih besar apabila seksyen tunggal tidak mencukupi. Walau bagaimanapun, bahagian yang dibina menunjukkan beberapa tingkah laku yang unik yang kod-kod semasa tidak mempunyai peruntukan yang komprehensif. Ini adalah samar-samar kerana tingkah laku keluli bergulung panas berbeza daripada keluli terbentuk sejuk. Penyelidikan ini akan menumpukan pada bahagian terbina terbuka atau bahagian I. Ahli struktur keluli terbentuk sejuk biasanya datang dengan kehadiran perforasi. Tebukan adalah lubang atau pembukaan yang dibuat pada keluli terbentuk sejuk untuk memudahkan kerja pembinaan. Ia biasanya dilengkapi dengan bentuk dan saiz yang berbeza berdasarkan fungsinya seperti menampung elektrik, paip dan penghawa dingin atau perkhidmatan pemanasan. Di samping itu, sangat sedikit kajian telah dijalankan untuk mengkaji bahagian terbina keluli terbentuk sejuk seperti back-to- lajur C-channel belakang tanpa jurang, lajur C-saluran belakang dengan lajur jurang, battened, dan berlapis. Oleh itu, matlamat penyelidikan ini adalah untuk menentukan beban utama keluli terbentuk sejuk dengan dan tanpa membuka melalui kajian eksperimen. Sejumlah 8 sampel yang dengan dan tanpa pembukaan diuji dalam eksperimen ini. Setiap anggota mempunyai ketebalan nominal 1.2 mm, panjang lajur 600 mm dan panjang web yang berbeza iaitu 103 mm dan 203 mm dimampatkan di antara hujung yang disokong hanya pada kedua-dua hujungnya. Hasil percubaan ini menunjukkan bahawa beban muktamad setiap sampel sangat berbeza pada kedudukan perforasi dan panjang web. Hasilnya dibentangkan dalam tiga bahagian yang merupakan beban berbanding anjakan menegak, beban vs. anjakan melintang dan tingkah laku tenggelam.

ABSTRACT

Cold-formed steel structural elements have been widely used in the construction industry and have emerged as a preferred economical solution for single-storey commercial and industrial buildings. Cold formed steel built-up sections are commonly used as compression elements to carry larger loads when a single section is insufficient. However, the built-up sections exhibit some unique buckling behaviors which the current codes do not have comprehensive provisions. This is ambiguous as the behavior of hot rolled steel is different from cold formed steel. This research will be concentrating on open built-up section or I-section. Structural members of cold-formed steel usually come with the presence of perforations. Perforations is a hole or opening that are made on the cold-formed steel to ease construction work. It usually provided with different shapes and size based on its function such as to accommodate electrical, plumbing and air conditioner or heating services In addition, very few studies have been carried out to study cold formed steel built-up sections such as back-to-back C-channel column without a gap, back-to-back C-channel column with a gap, battened, and laced columns. Thus, the aim of this research is to determine the ultimate load of cold-formed steel with and without opening through experimental studies. A total of 8 samples that with and without opening were tested in this experiment. Each member has nominal thickness of 1.2 mm, column length of 600 mm and different web length which is 103 mm and 203 mm were compressed between a simply supported ends at both end. The result of this experiment shows that the ultimate load of each sample varies greatly on the perforation position and the web length. The result is presented in three section which are load vs. vertical displacement, load vs. horizontal displacement and buckling behavior.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

LBW	Lateral back
CFS	Cold-Formed steel
FKASA	Fakulti Kejuruteraan Alam Dan Sumber Alam
n.d	No date
LBF	Lateral torsional buckling at top support (front)
LTF	Lateral torsional buckling at top support (front)
DTF	Distortional buckling at top support (front)
DTB	Distortional buckling at top support (back)
DMF	Distortional buckling at middle span (front)
DBF	Distortional buckling at bottom support (front)
DBB	Distortional buckling at bottom support (back)
WMB	Warping buckling at middle span (back)
WMF	Warping buckling at middle span (front)
WBF	Warping buckling at bottom support (front)
WTB	Warping buckling at top support (back)
FE	Finite Element
SFIA	Steel Framing Industry Association
CH1	Transducer 1 – Vertical Displacement
CH2	Transducer 2 – Horizontal Displacement
CH3	Transducer 3- Horizontal Displacement

CHAPTER 1

INTRODUCTION

1.1 Introduction

Cold–formed steel members have been increasingly used in many industrial, residential and commercial steel buildings due to their relatively good strength to weight ratio and speedy construction. Further, unlike conventional hot–rolled sections, cold–rolled sections are usually thinner and are generally associated with high strength and stiffness to weight ratios, as a result of rolling process at ambient temperature. According to Steel Framing Alliance report, the use of cold-formed steel framing in the recent years has increased expressively in residential, commercial and industrial construction. Statistics shows that cold-formed steel framing occupies 39% of commercial applications, with 81% of all non-load bearing cases and 23% of structural applications. Hence, in comparison to hot-rolled steel members, cold-formed steel members are more vulnerable to instabilities like local, global and distortional buckling. In terms of physical characteristics, cold rolled steels are typically harder and stronger than standard hot rolled steels. As the metal is shaped at the lower temperatures, the steel's hardness, resistance against tension breaking, and resistance against deformation are all increased due to work hardening.

There have been some significant developments in cold-formed steel structures over the past few decades, mainly due to improving technology of manufacture (higher quality steels, more complex section shapes, improved forming technology) and corrosion protection. This leads to greater competitiveness of this structural solution which has been translated into an increasing market share throughout the world. Cold-formed steel members are made from cold bent steel sheets of 0.5–3.0 mm thickness. Researchers have been focused on the behaviour of cold-formed steel structures. Regarding the behaviour of cold-formed steel columns, research has been mainly focused on open

sections, such as plain and lipped channels, channels with simple and complex edge stiffeners, with and without holes and angles as shown in Figure 1.1. More recently built-up members have also been investigated by some researchers

The main advantages of cold-formed steel systems as non-structural and structural ,low seismic forces due to lightness of the material, practicability in the field (easy erection),dimensional superiority high level of ductility and energy absorption capacity and environmental issues.

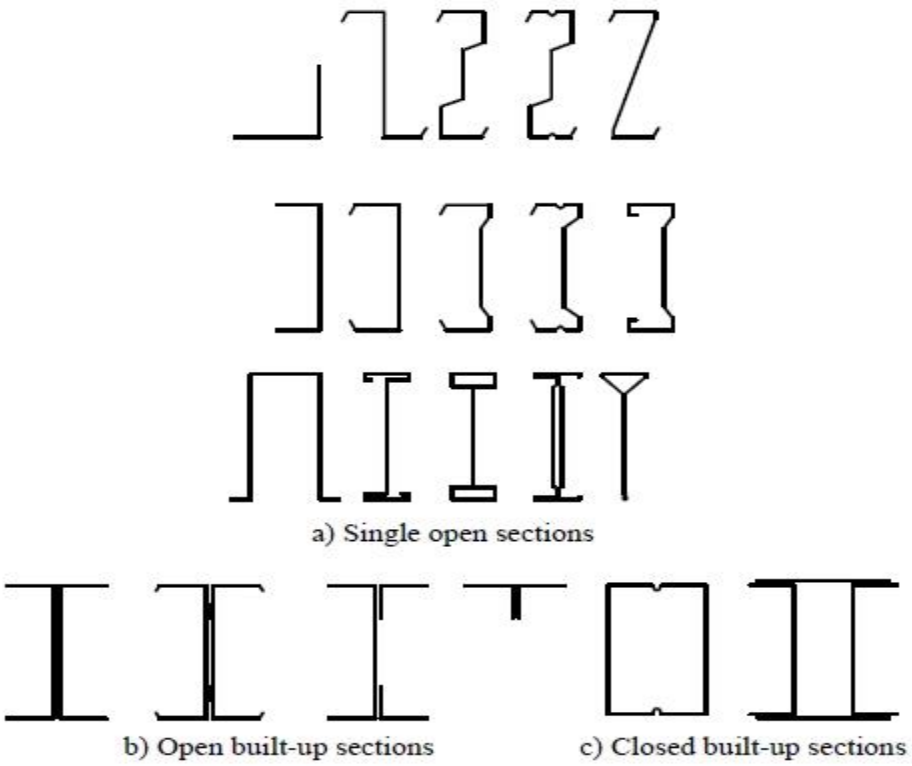

Figure 1.1 Variation of cold-formed steel

Source: (Dubina, et al., 2012)

Openings are often introduced in structural members to facilitate the building services such as pipeline, electric wire and heating conduits, as well as inspection and maintenance work of buildings. These openings are usually pre-punched perforations, which could lead to the redistribution of membrane stresses in the members and greatly influence the elastic stiffness and ultimate strengths of structural members. The behaviour of perforated structural members significantly depends on the shape, size, location and number of openings.

1.1.1 Example of Usage of Cold-formed Steel

Cold-formed steel column are normally use in structural around the world as shown in Figure 1.2 and in Figure 1.3 from the column to the roof overall is using cold-formed steel column. This will give an advantage to the client as the project will not use long period of time. In Malaysia the use of cold-formed steel is limited because of people are not aware of the advantages of cold-form steel.

Figure 1.2 House made up from cold-formed steel

Source: (Georgieva, et al., 2012)

Figure 1.3 Cold-formed steel framing

Source: (Satpute & Varghese, 2012)

REFERENCES

Boube, L., Yu, W. W. & A., R., 2010. *Cold-Formed Steel Design, Fourth Edition.*

Craveiro, D., Rodrigues, J. C. & L., 2016. Buckling resistance of axially loaded cold-formed steel columns. *Thin-Walled Structures 106(2016)358–375.*

Dubina, D., Ungureanu, V. & Landolfo, R., 2012. Design of Cold-formed Steel Structures. *Eurocode 3: Design of Steel Structures Part 1-3 - Design of Cold-formed Steel Structures.*

Feng, R., Mou, X., Chen, A. & Maa, Y., 2016. Tests of aluminium alloy CHS columns with circular openings. *Thin-WalledStructures109(2016)113–131.*

Fratamico, D. C. et al., 2018. Experiments on the global buckling and collapse of built-up cold-formed. *Journal of Constructional Steel Research 144 (2018) 65–80.*

Georgieva, I., Schueremansa, L. & Pyl, L., 2012. Composed columns from cold-formed steel Z-profiles: Experiments and code-based predictions of the overall compression capacity. *Engineering Structures 37 (2012) 125–134.*

Georgieva, I., Schueremansa, L., Vandewallea, L. & Pyl, L., 2012. Design of built-up cold-formed steel columns according to the direct strength method. *Procedia Engineering 40 (2012) 119 – 124.*

Javed, M. F., Hafizah, N., Memon, A. S. & Jameel, M., 2017. Recent research on cold-formed steel beams and columns subjected to elevated temperature: A review. *Construction and Building Materials 144 (2017) 686–701.*

Kesawan, S., Mahendran, M., Dias, Y. & Zhao, W. B., 2017. Compression tests of built-up cold-formed steel hollow flange sections. *Thin-Walled Structures 116 (2017) 180–193.*

Kulatunga, M. P., Macdonald, M., Rhodes, J. & Harrison, D. K., 2014. Load capacity of cold-formed column members of lipped channel. *Thin-Walled Structures 80(2014)1–12.*

Li, Y., Li, Y., Wang, S. & Shen, Z., 2014. Ultimateload-carryingcapacityofcold-formedthin-walledcolumns. *Thin-Walled Structures 79(2014) 202–217.*

Lu, Y., Zhou, T. & Wu, H., 2017. Experimental investigation and a novel direct strength method for. *Thin-Walled Structures 112 (2017) 125–139.*

Moen, C. D. & Schafer, B. W., 2008. Experiments on cold-formed steel columns with holes. *Thin-Walled Structures 46 (2008) 1164–1182.*

Muftah, F., Hisyam, M. S. & Mohammad, S., 2014. ULTIMATE LOAD OF BUILT-UP COLD FORMED STEEL COLUMN. *ARPN Journal of Engineering and Applied Sciences.*

Satpute, R. & Varghese, V., 2012. Building design using cold formed steel section.. *International Refereed Journal of Engineering and Science (IRJES), 1(2), pp.1-16.*.

SFIA, n.d. *Steel Framing Industry Association.* [Online].

Soyoz, S. & Karabulut, B., 2017. Experimental and analytical studies on different configurations of cold-formed steel structures. *Journal of Constructional Steel Research Volume 133, June 2017, Pages 535-546.*

Stone, T. A. & Laboube, R. A., 2005. Behavior of cold-formed steel built-up I-sections. *Thin-Walled Structures 43 (2005) 1805–1817.*

Teh, L. H. & Yazici, V., 2013. Shear lag and eccentricity effects of bolted connections in cold-formed steel sections. *Engineering Structures, 52 536-544.*.

Vijayanand, S. & Anbarasu, M., 2017. Effect of Spacers on Ultimate Strength and Behavior of Cold-Formed Steel Built-up Columns. *Procedia Engineering 173 (2017) 1423 – 1430.*

Whittle, J. & Ramseyer, C., 2009. Bucklingcapacitiesofaxiallyloaded,cold-formed,built-upC-channels. *Thin-Walled Structures 47(2009)190–201.*

Young, B., Chen & Ju, 2008. Design of Cold-Formed Steel Built-Up Closed Sections with. *J. Struct. Eng. 2008.134:727-737.*.

Yuana, W. B., Yua, N. T. & Li, L. Y., 2017. Distortional buckling of perforated cold-formed steel channel-section beams. *International Journal of Mechanical Sciences 126 (2017) 255–260.*

Zhou, W. & Jiang, L., 2017. Distortional buckling of cold-formed lipped channel columns subjected to axial compression.. *Steel and Composite Structures, 23(3), pp.331-338.*.